

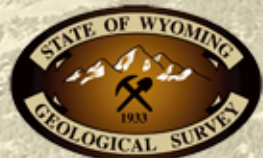
Characterization of the Highest-Priority Geological CO₂ Storage Sites and Formations in Wyoming



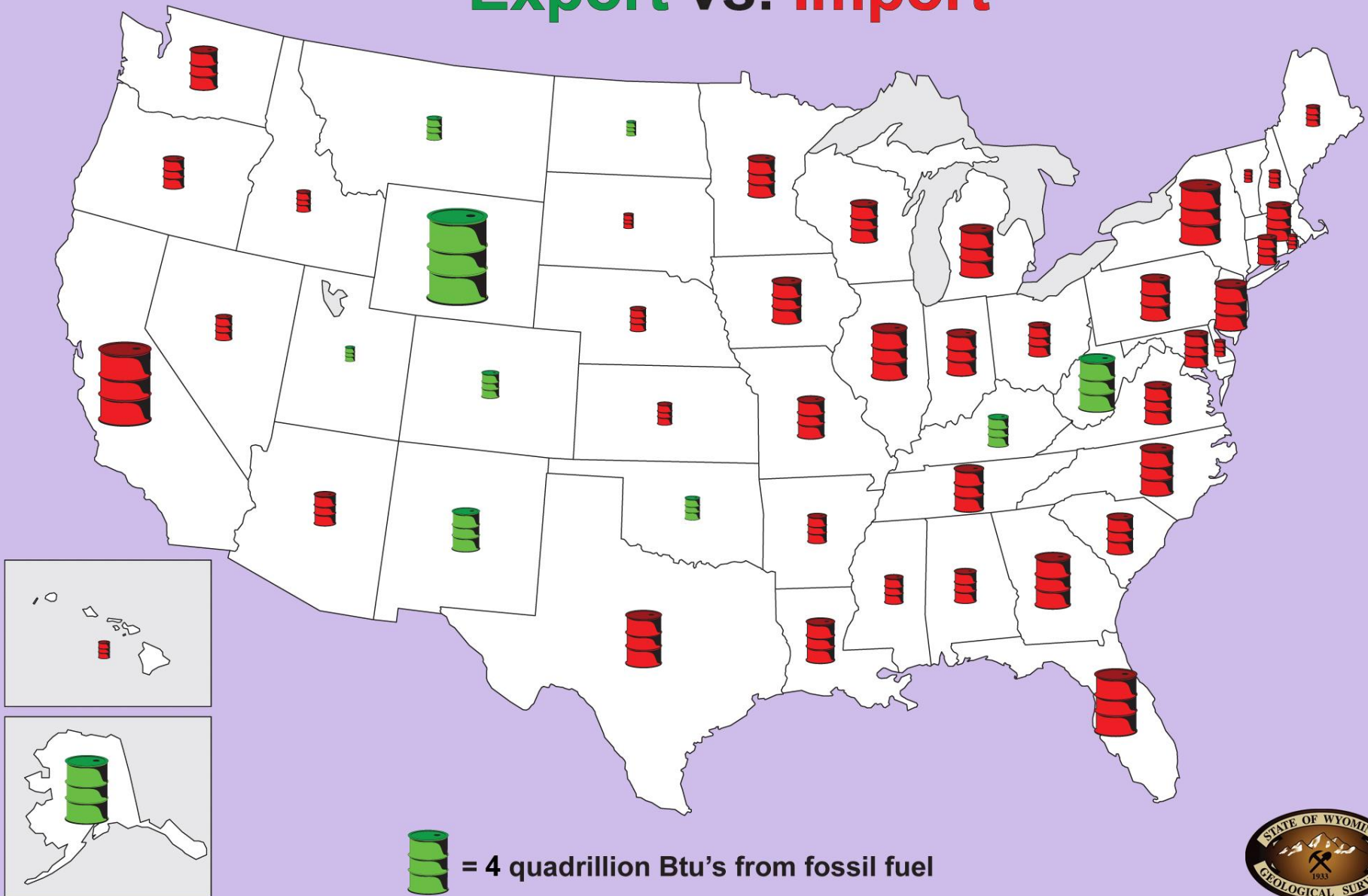
Ronald C. Surdam
Director, Carbon Management Institute



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Net Domestic Energy Export vs. Import



U.S. Energy Imports

2006

Rank	Country or State of Origin	Crude Oil		Natural Gas		Coal		Total Quadrillion Btu
		Production Million Bbl/year	Quadrillion Btu	Production Trillion Cubic ft/year	Quadrillion Btu	Production million tons/year	Quadrillion Btu	
1	Wyoming	52.93	0.28	1.75	1.77	446.74	7.96	10.01
2	Canada	648.97	3.41	3.59	3.63	1.49	0.04	7.08
3	West Virginia	1.83	0.01	0.22	0.22	152.37	3.91	4.14
4	Mexico	575.61	3.02	0.01	0.01	0.00	0.00	3.04
5	Saudi Arabia	519.40	2.73	0.00	0.00	0.00	0.00	2.73
6	Venezuela	416.83	2.19	0.00	0.00	3.07	0.08	2.27
7	Nigeria	378.51	1.99	0.06	0.06	0.00	0.00	2.05
8	Alaska	270.47	1.42	0.42	0.43	0.00	0.00	1.85
9	Iraq	201.85	1.06	0.00	0.00	0.00	0.00	1.06
10	Angola	187.25	0.98	0.00	0.00	0.00	0.00	0.98
Total		3,253.61	17.08	6.05	6.12	603.67	11.99	35.19

Note: Total may not equal sum of components because of independent rounding.

Coal imports include coal to Puerto Rico and the Virgin Islands.

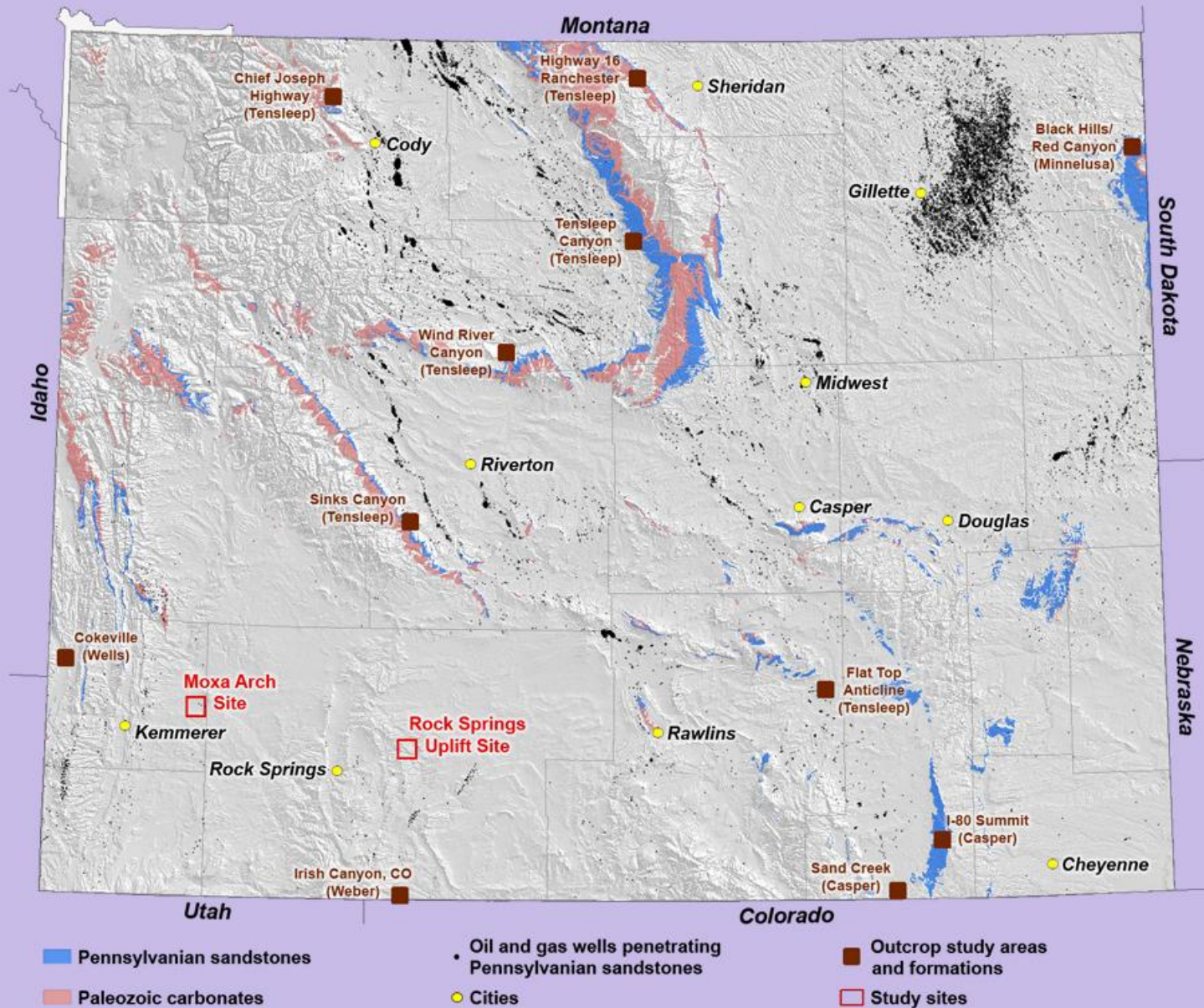
Source: Bureau of the Census, U.S. Department of Commerce, *Monthly Report IM 145*.

EIA, U.S. Natural Gas Imports by Country

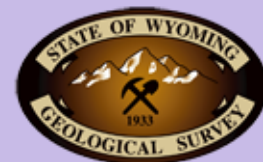
EIA, U.S. Crude oil Net Imports by Country

EIA, Gross Heat Content of Coal Production, Most Recent Annual Estimates, 1980-2006

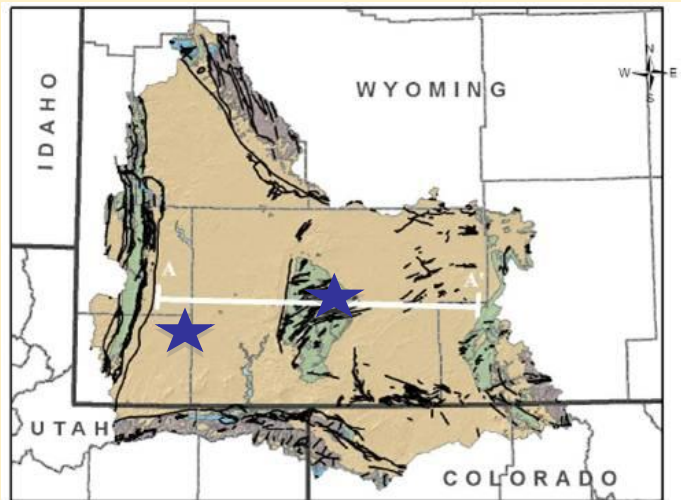




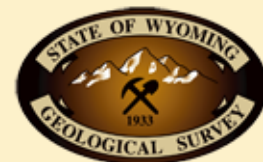
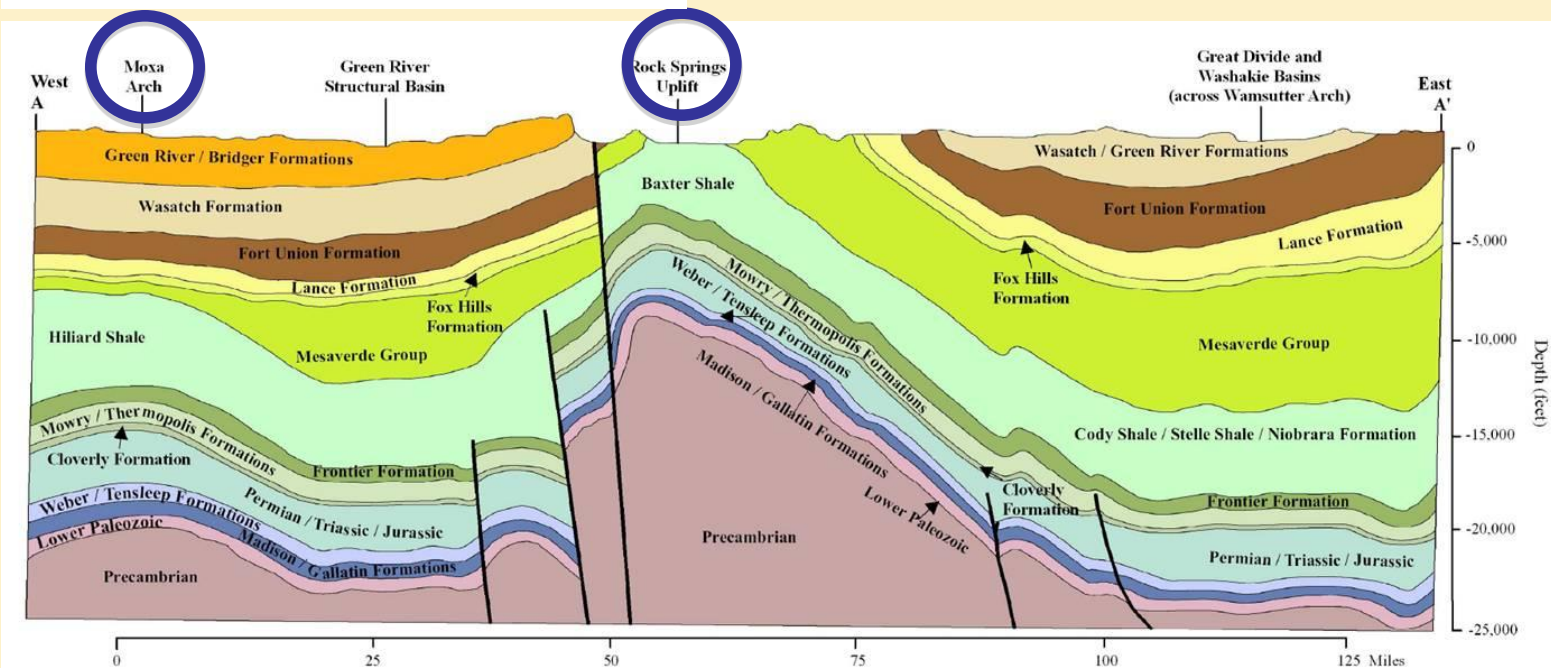
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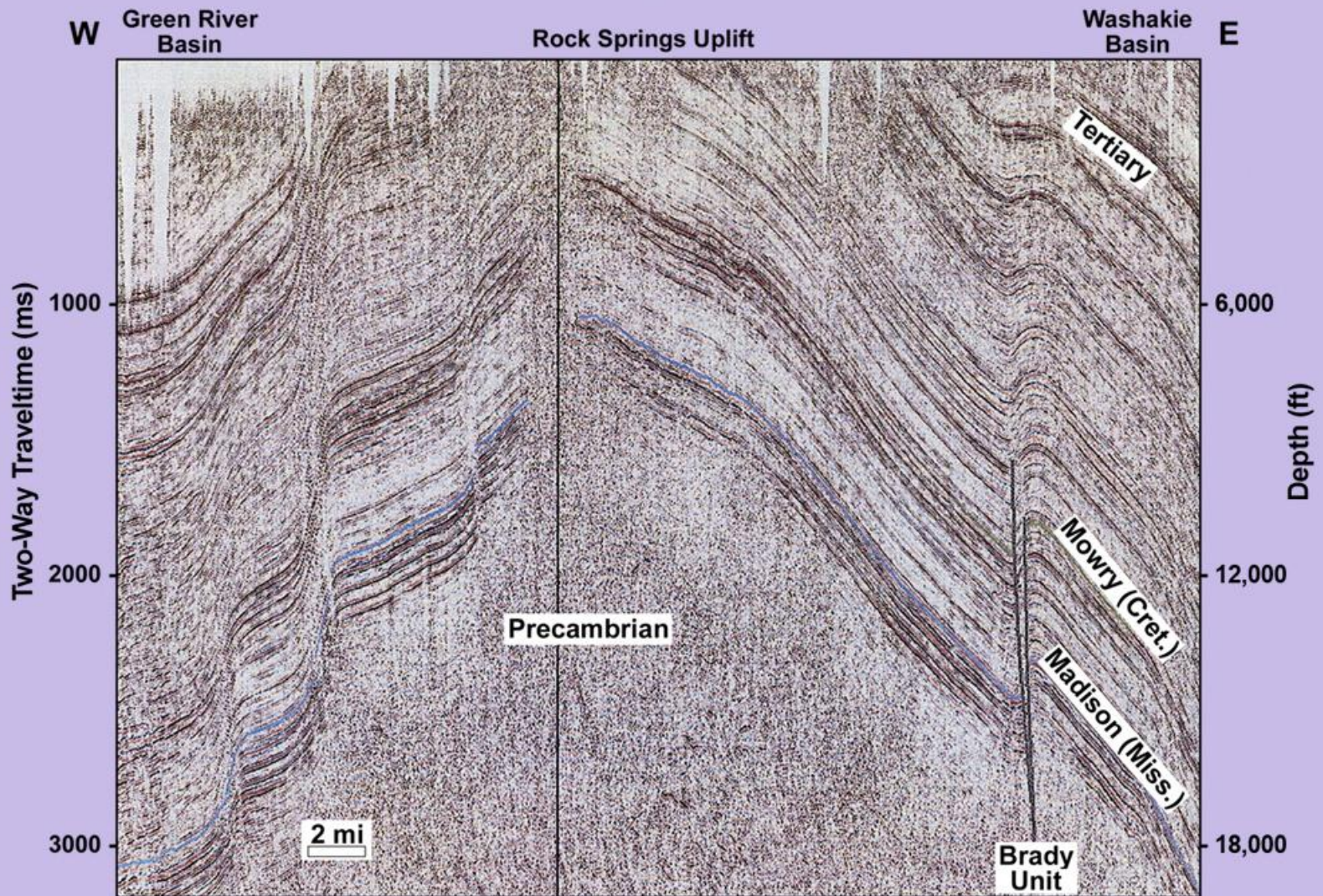


Carbon Capture Potential In Southwest Wyoming

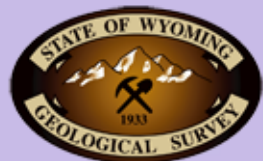


WSGS, UW, State, and DOE-funded research identified two high-capacity sites in southwest Wyoming:
Rock Springs Uplift & Moxa Arch

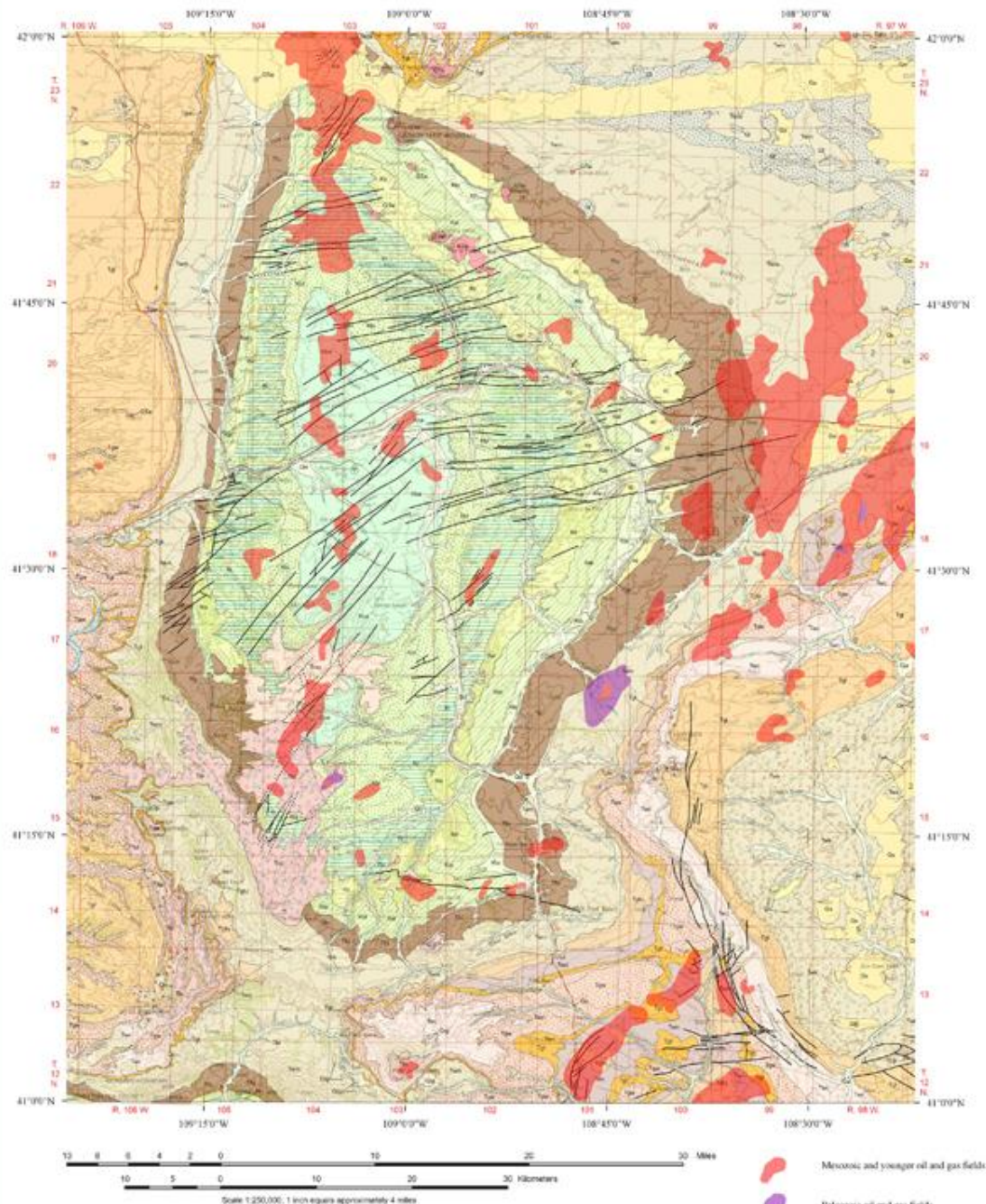




Surdam, R.C. & Jiao, Z., 2007, The Rock Springs Uplift: An outstanding geological CO₂ sequestration site in southwest Wyoming: Wyoming State Geological Survey Challenges in Geologic Resource Development No. 2, 31 p.



GEOLOGIC MAP AND OIL AND GAS FIELDS OF THE ROCK SPRINGS UPLIFT AREA, SWEETWATER COUNTY, SOUTHWESTERN WYOMING



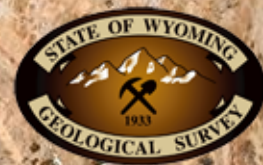
Surdam, R.C. & Jiao, Z.,
2007, The Rock Springs
Uplift: An outstanding
geological CO₂
sequestration site in
southwest Wyoming:
Wyoming State
Geological Survey
Challenges in Geologic
Resource Development
No. 2, 31 p.





Photo by Z. Jiao, WSGS.

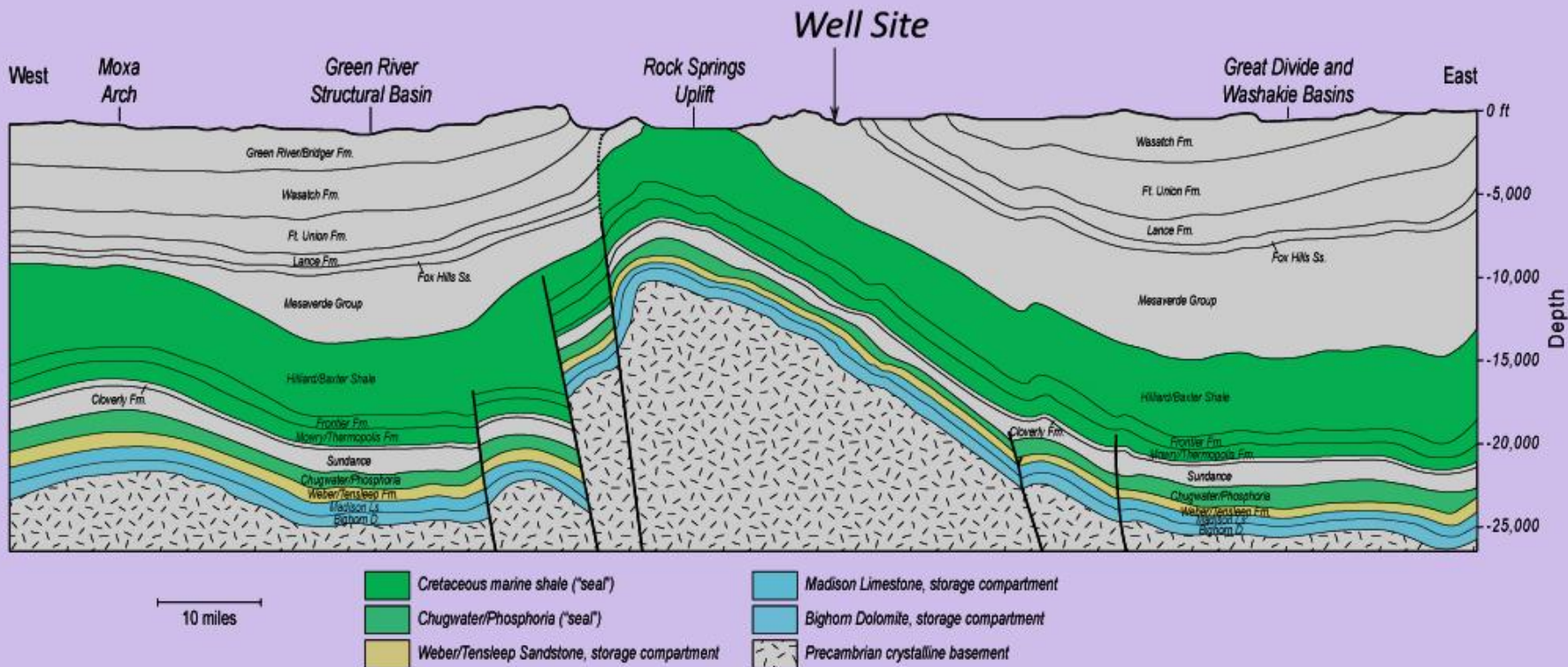
Photo by Meg Ewald, WSGS.

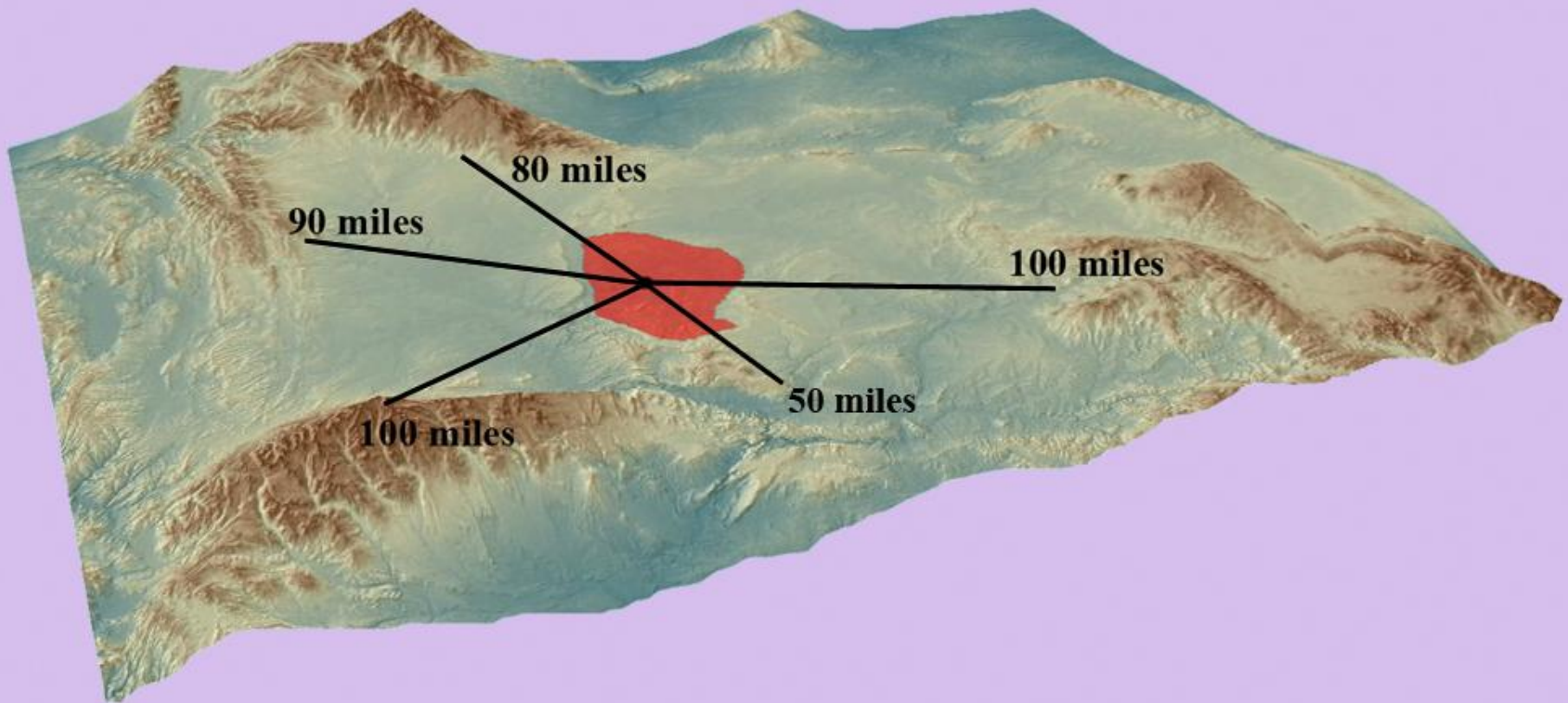


200 μm

A high-magnification micrograph showing a complex, porous surface structure. The surface is composed of numerous light-colored, irregularly shaped particles or grains, which are interconnected by a network of darker, blueish-grey material. The overall appearance is highly textured and granular. A yellow scale bar is positioned at the top left, indicating a length of 200 μm.

Weber 6502'



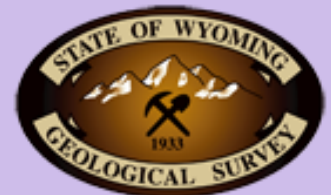


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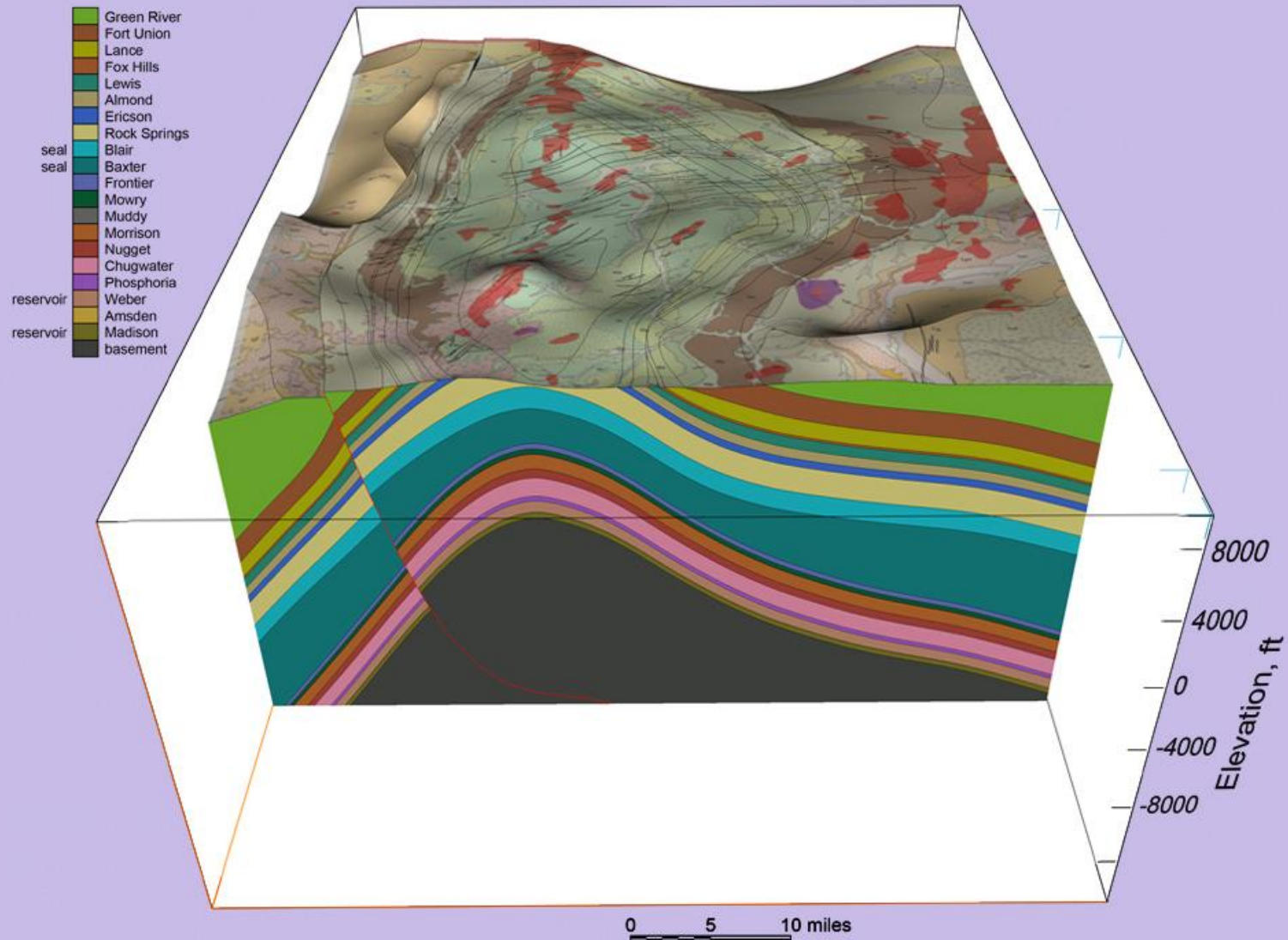


Rock Springs Uplift: an outstanding geological CO₂ sequestration site in southwestern Wyoming

- **Thick saline aquifer sequence overlain by thick sealing lithologies.**
- **Doubly-plunging anticline characterized by more than 10,000 ft of closed structural relief.**
- **Huge area (50 x 35 mile).**
- **Required reservoir conditions; including, but not limited to fluid chemistry, porosity (pore space), fluid-flow characteristics, temperature and pressure (i.e., regional burial history).**

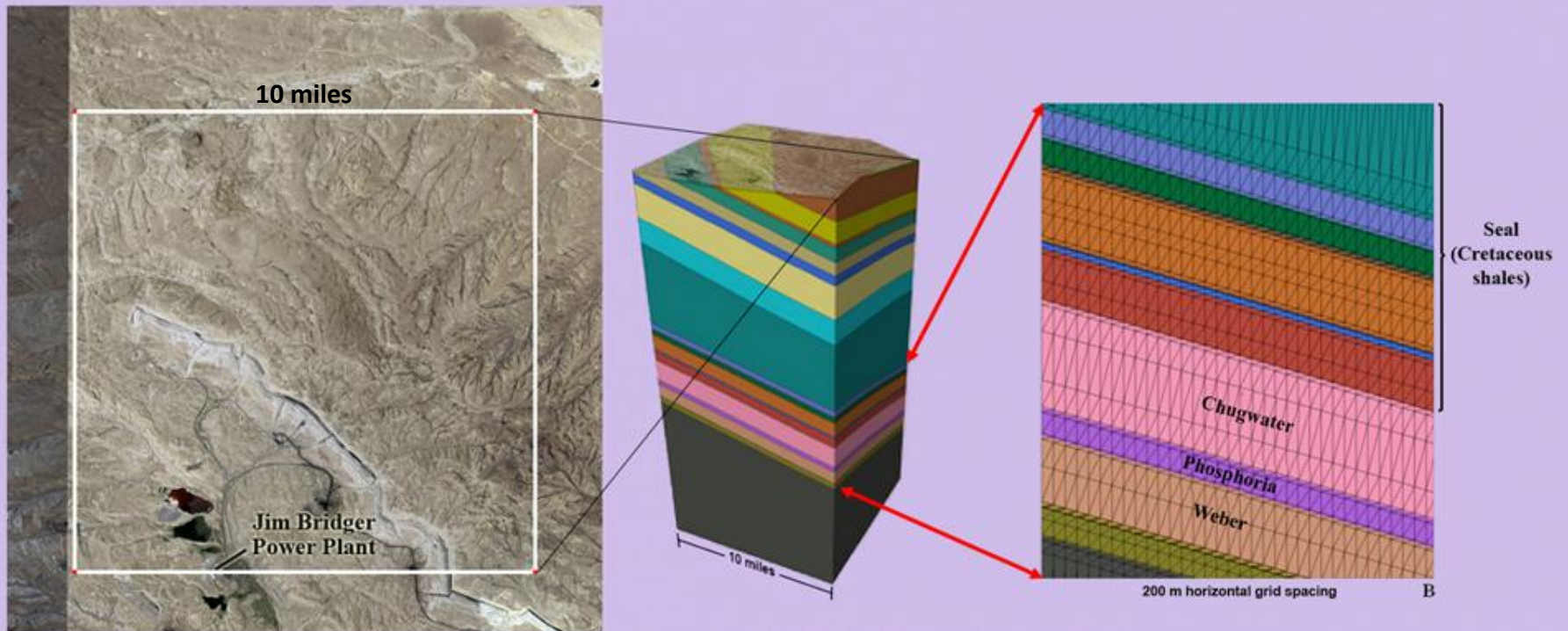


Rock Springs Uplift, Wyoming



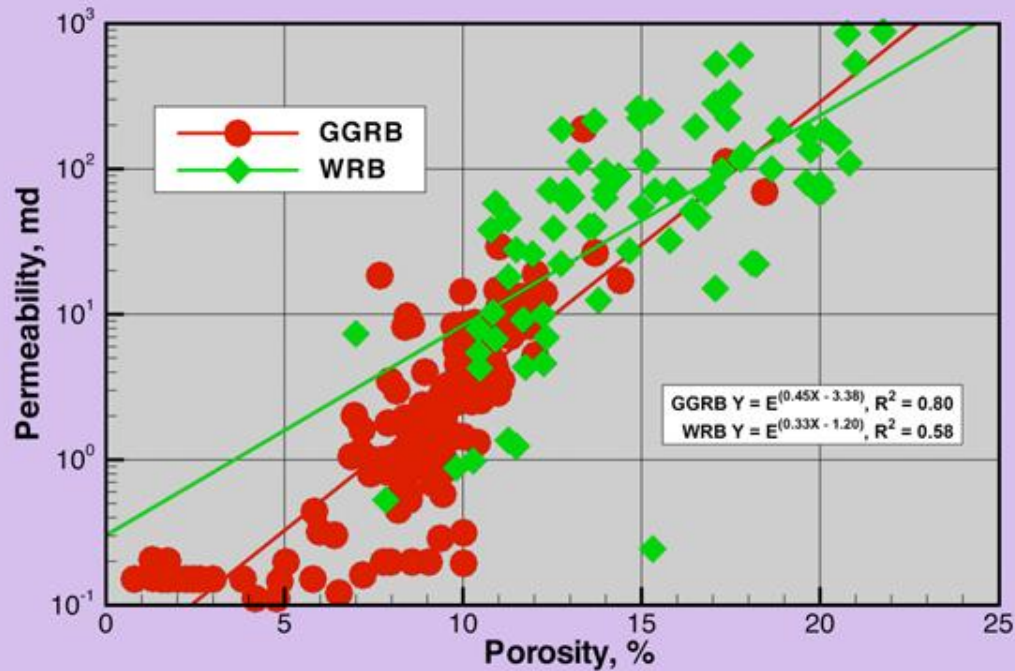
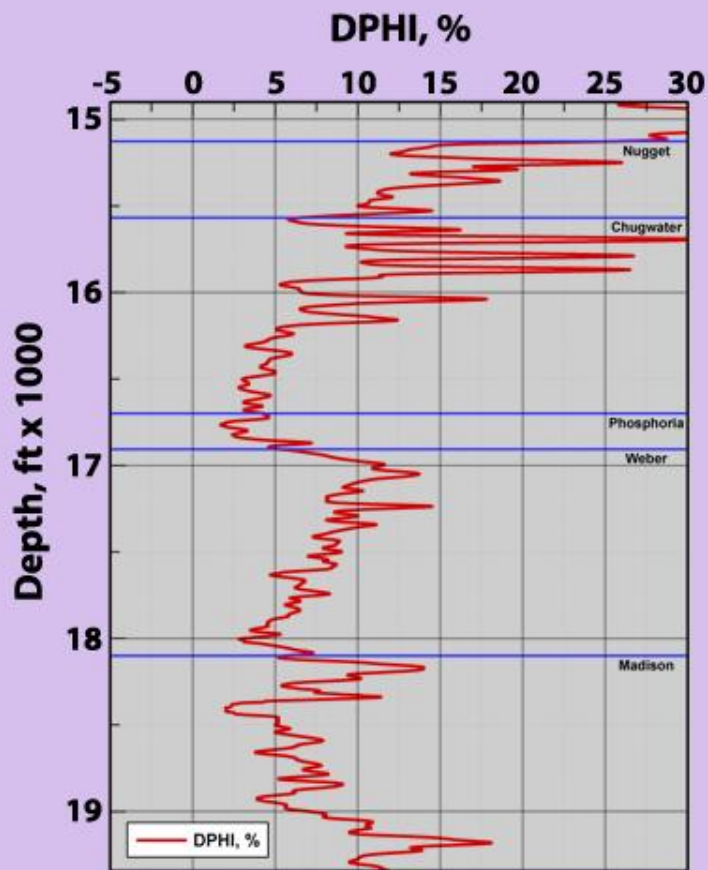
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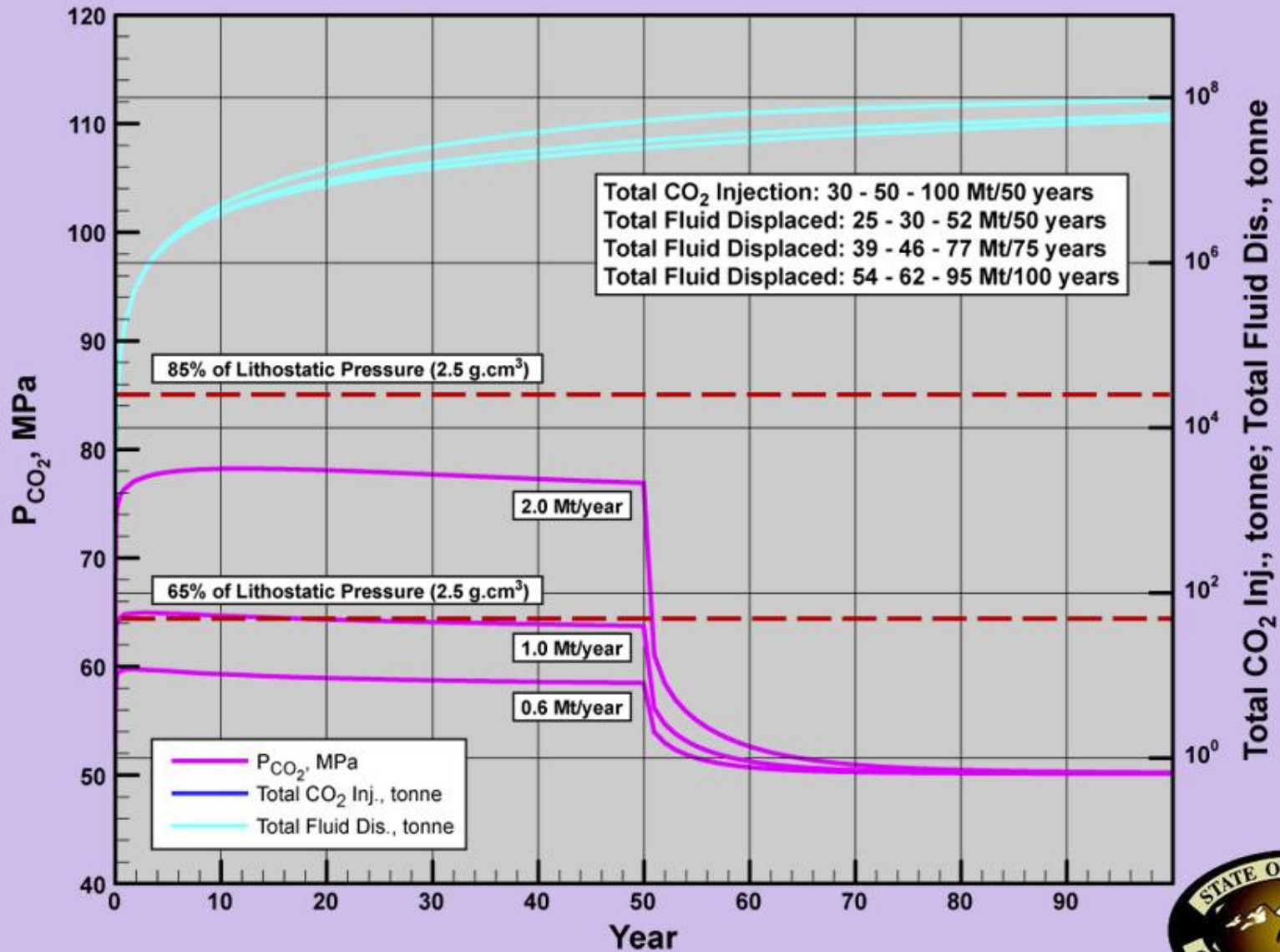




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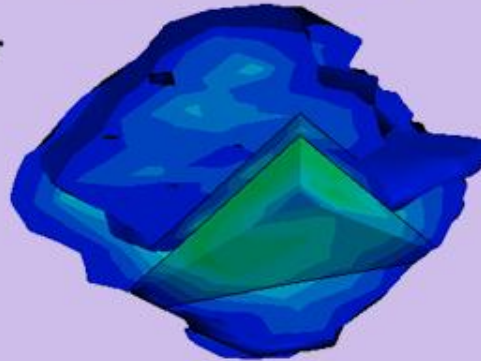


CO₂ Injection Simulation Results from FEHM for the Weber Sandstone, Rock Springs Uplift
Injection Interval 700 ft, Porosity 10%, Relative Permeability 1 md,
Injection Rate 10.57x3 kg/s, 0.6 - 1.0 - 2.0 Mt/year, 1 Injection Well

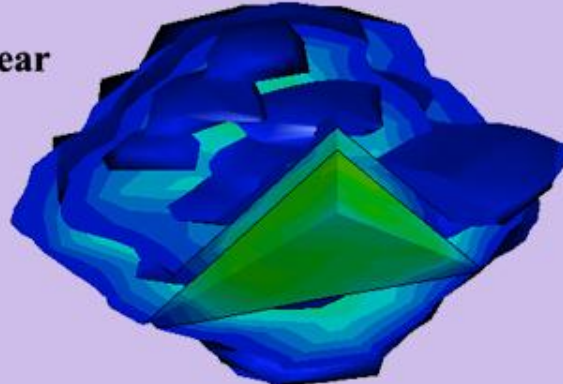


Geological CO₂ Sequestration, after 50 Years Injection, Weber Sandstone Rock Springs Uplift, 9 Injection Wells

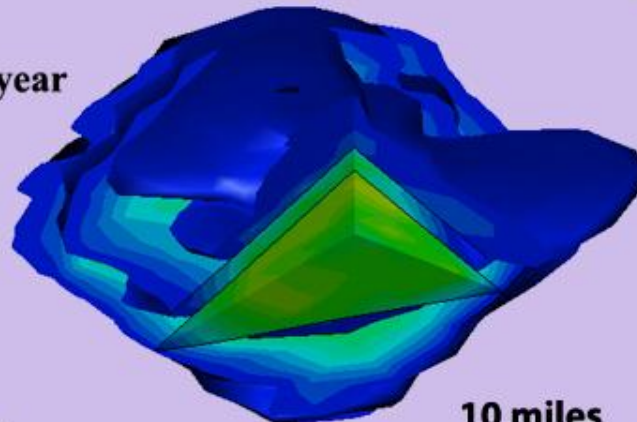
5 Mt/year



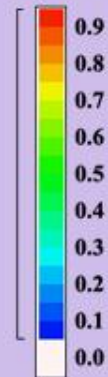
10 Mt/year



15 Mt/year



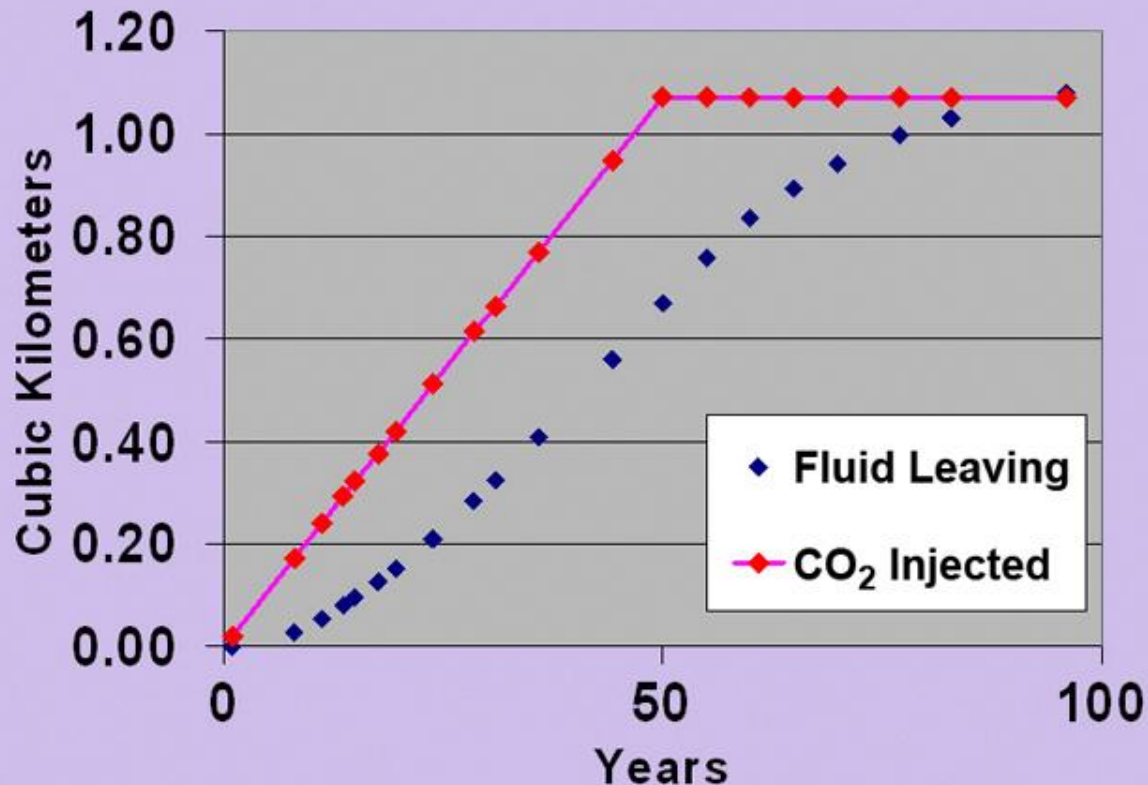
CO₂ Saturation



10 miles



Injected CO₂ versus fluid leaving the domain



Scale:

750 Mt of CO₂ displaces
~1 cubic kilometer.

1 cubic kilometer of
displaced fluids is
~6,000,000,000 barrels

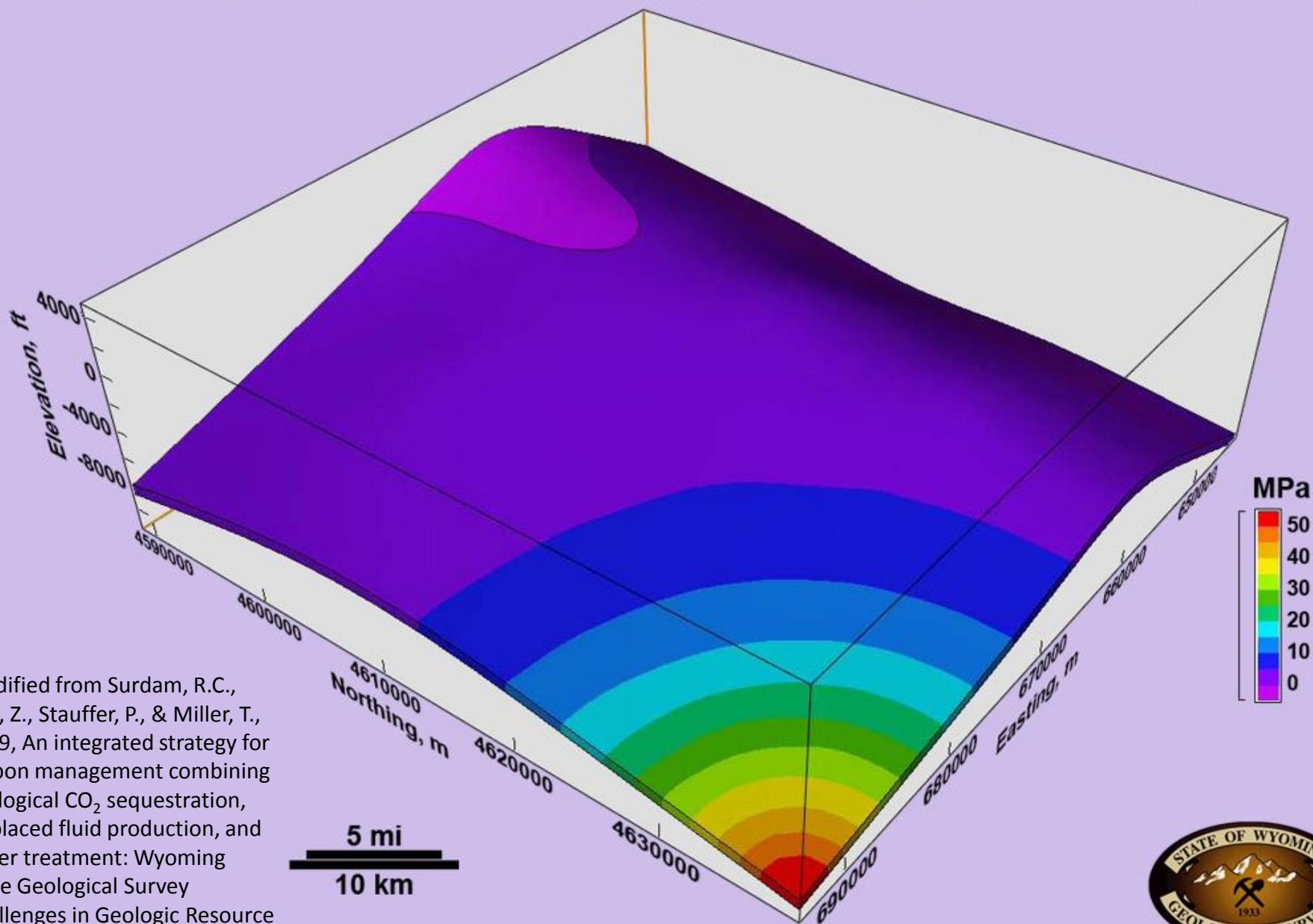
Salt Creek Oil production
(the largest oil field in
Wyoming) is ~680,000,000
barrels (120 yrs)

1 cubic kilometer of water
is ~710,000 acre-feet.

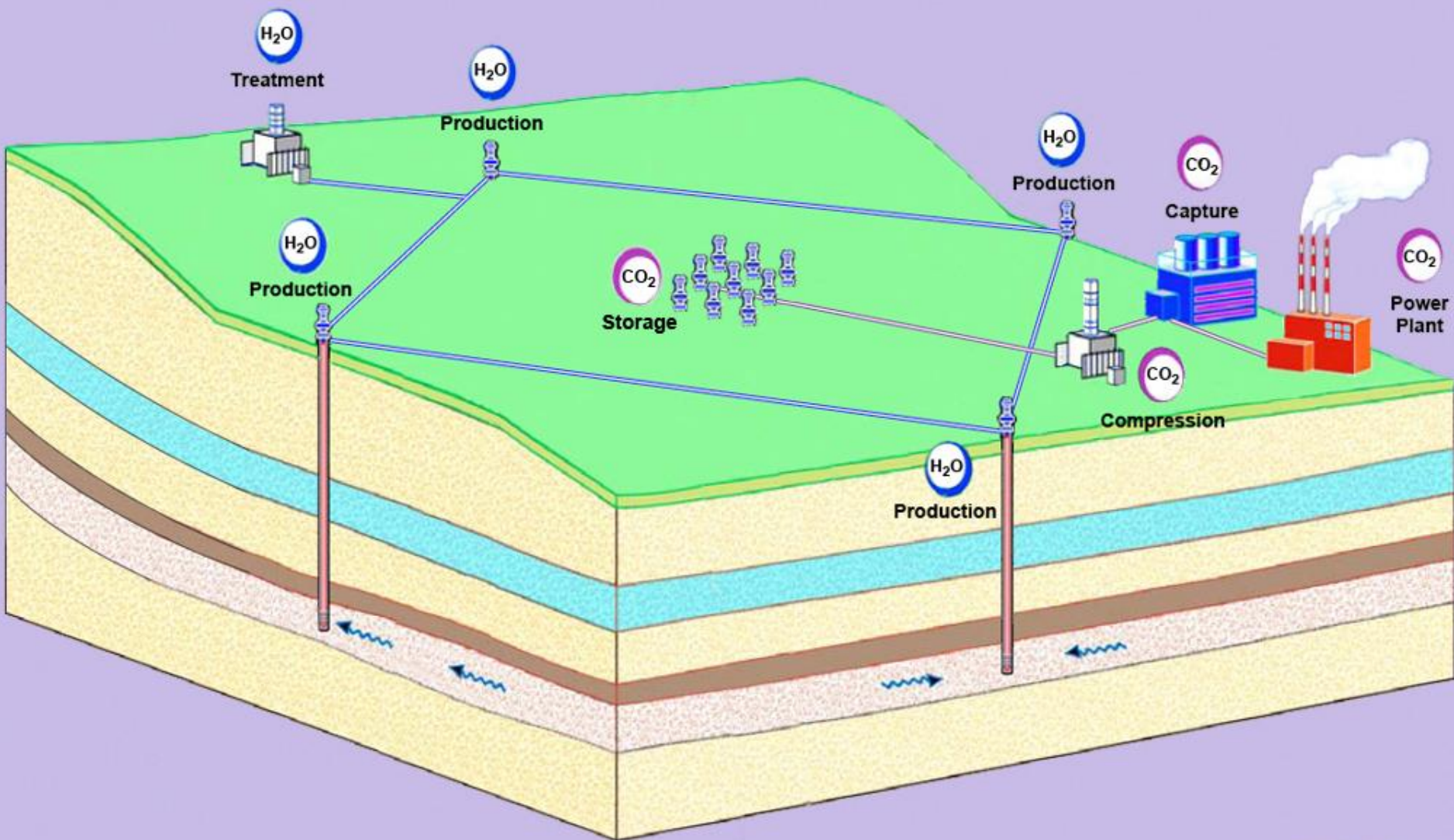
Boysen Reservoir is 792,000
acre-feet.



Change in pressure after 50 years of CO₂ injection, 15 mt/y, Weber Sandstone, RSU

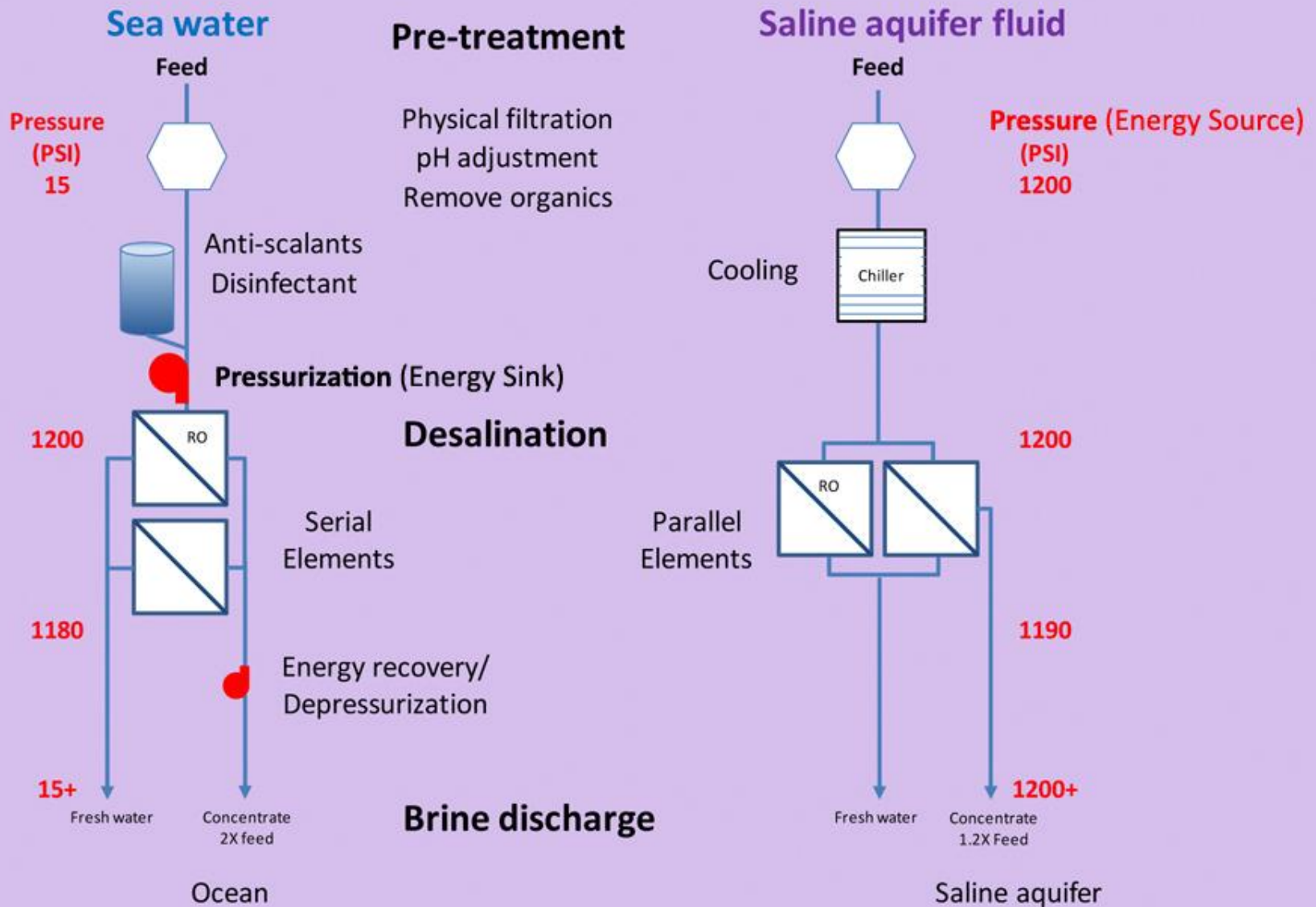


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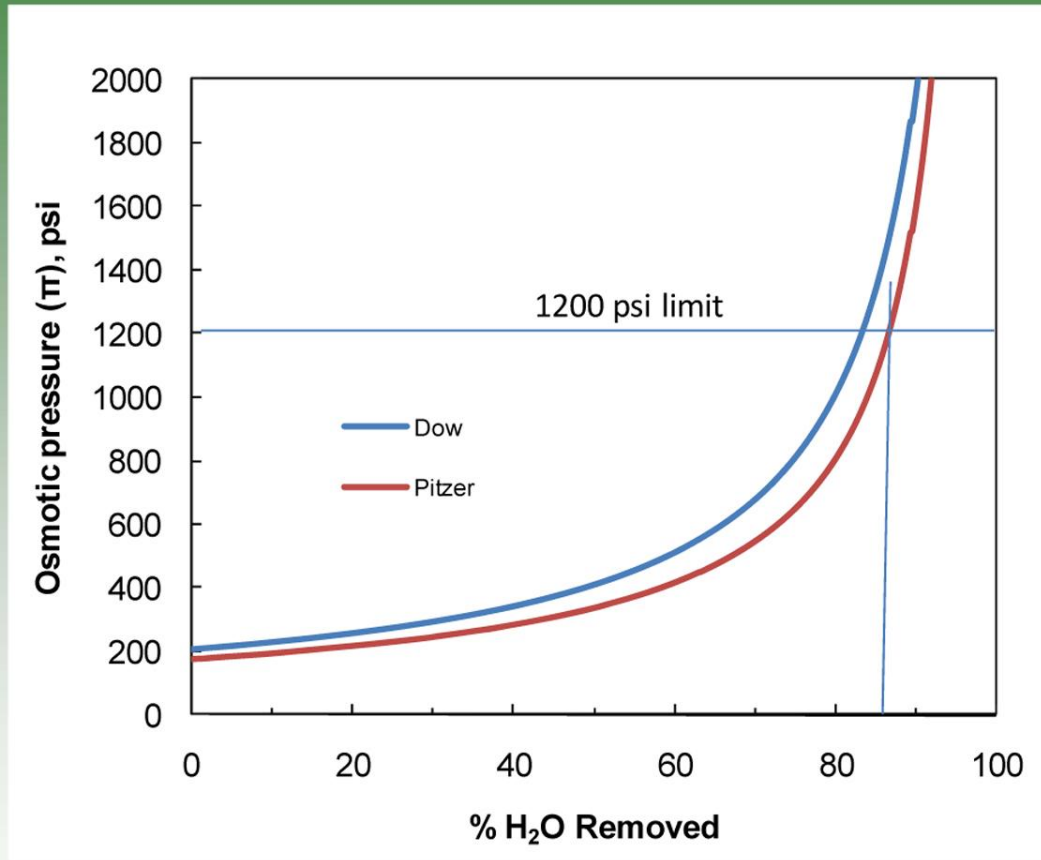
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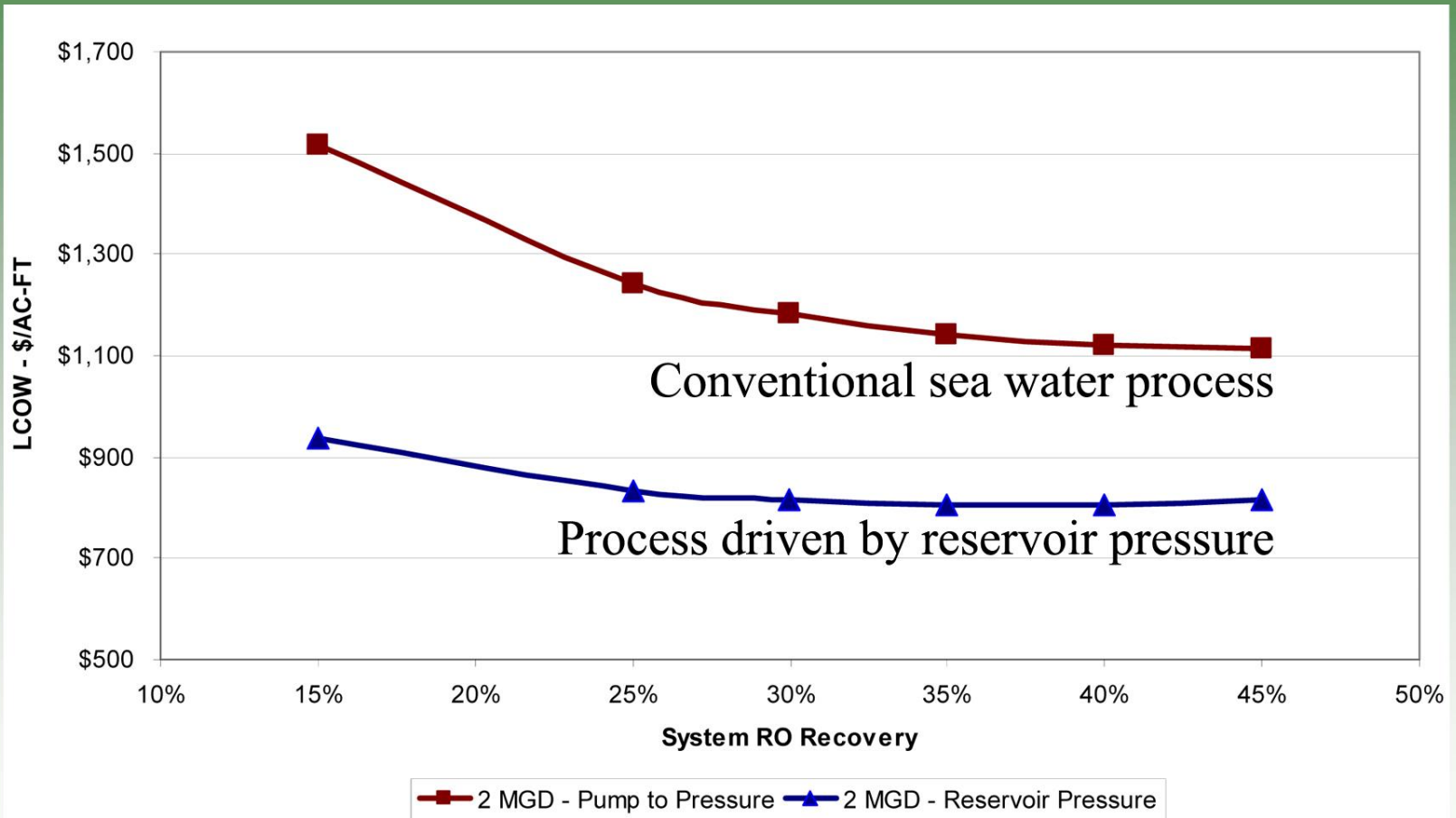
modified from Wolery, T.J., Aines, R.D., Hao, Y., Bourcier, W., Wolfe, T., and Haussman, C., 2009

Osmotic pressure at 50°C (WY Sublette Co. #2) (Na-Cl-SO₄ brine, Tensleep/Weber Formation)



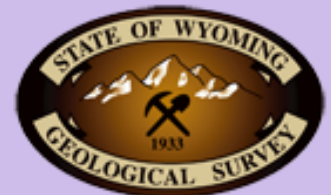
Osmotic pressure

Water costs are relatively low when process energy is supplied by reservoir pressure



Conclusions

- The most critical problem with commercial scale geological CO₂ sequestration is management of displaced fluids. To solve this problem, the Wyoming State Geological Survey proposes a strategy that includes integration of fluid production/water treatment with injection of CO₂.
- The greatest uncertainty in numerically simulating CO₂ sequestration processes is characterizing geological heterogeneity in 3 dimensions.



The WY-CUSP Partnership

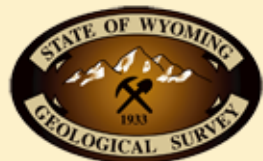
CMI – WSGS – SER is conducting one of the DOE sequestration characterization studies on the Rock Springs Uplift, Wyoming.

The Primary Objectives of this study are

- 1) to significantly reduce the numerical simulation uncertainty by documenting the geological heterogeneity in 3-D, and
- 2) to design the water treatment facility required to solve the displacement fluid problem.
- 3) to prepare a sub-commercial CO₂ storage demonstration on the Rock Springs Uplift (i.e., Phase II of WY-CUSP).



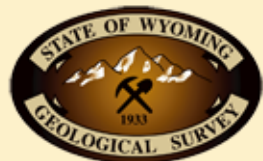
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Basic elements of the Rock Springs Uplift characterization project are the acquisition of a 3D seismic survey and a stratigraphic test at the selected geological CO₂ sequestration site.



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WY-CUSP Emphasis (Phase I)

- Data retrieval, evaluation and interpretation.
- Description of the 3-D geological heterogeneity characterizing the RSU site.
- Substantial uncertainty reduction of RSU numerical simulations (i.e., risk reduction).
- Design of custom fluid treatment technology for RSU Weber/Madison brines.
- Preparation of sub-commercial CO₂ storage demonstration (i.e., 1+ Mt CO₂/yr).



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